

# Does Maternal Smoking Have a Negative Physiological Effect on Breastfeeding? The Epidemiological Evidence

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**ABSTRACT: Background:** Women who smoke are less likely to breastfeed their children than nonsmokers. It is thought that nicotine has a negative effect on breastmilk supply by suppressing prolactin levels. The aim of this review was to assess the epidemiological evidence that maternal smoking has a negative physiological effect on breastfeeding. **Methods:** The following data sources were searched: The Cochrane Library, Medline, CINAHL, Current Contents, Psycinfo, Sociological Abstracts and the Lactation Resource Centre (Australian Breastfeeding Association) using the key words "smoking" and "breastfeeding" or "infant feeding." The Journal of Human Lactation and Birth were hand searched. **Results:** Women who smoke are less likely to intend to breastfeed, less likely to initiate breastfeeding, and likely to breastfeed for a shorter duration than nonsmokers. Several studies have found a dose-response relationship between the number of cigarettes smoked each day and breastfeeding intention, initiation, and duration that persists after adjusting for confounding factors. In some population groups a high proportion of smokers breastfeed successfully. **Conclusions:** The association between maternal smoking and lack of breastfeeding is consistent across different study designs in a range of countries. Given that women who smoke are less likely to intend to breastfeed, however, it cannot be assumed that the relationship between smoking and duration of breastfeeding is a physiological one. If smoking had a consistent negative physiological effect on lactation, one would not expect to see such wide variations in breastfeeding rates among women who smoke. Therefore, it is likely that psychosocial factors are largely responsible for the lower rates of breastfeeding found in women who smoke compared with those who do not. (BIRTH 29:2 June 2002)

Cigarette smoking is an important issue for maternal and child health. Rates of smoking in young women in many industrialized countries are comparable with or higher than those among young men, and rates are also rising in many developing countries (1). The deleterious effects of smoking on women's reproductive health include increased rates of infertility and

premature delivery, and infants are more likely to be small-for-gestational age and at increased risk of stillbirth (1).

Nicotine levels in breastmilk of women who smoke are almost three times higher than the level in the mother's blood (2). Breastfed infants of smokers have been found to have median urinary cotinine (a metabolite of nicotine) levels tenfold higher than those of artificially fed infants of smoking mothers (3,4). Despite this evidence, it is still recommended that women who smoke breastfeed their infants because the risks of not breastfeeding are greater than the risks of continuing to breastfeed (5-7).

Although the World Health Organization recommends exclusive breastfeeding for the first 6 months of life, many women do not start breastfeeding or

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give up prematurely. Women who smoke cigarettes are less likely to breastfeed than nonsmokers (8). Horta et al's recent meta-analysis examined the relationship between smoking and the risk of giving up breastfeeding by 3 months among women who had initiated breastfeeding (9). From 13 studies they reported a pooled odds ratio of 1.93 (95% CI, 1.55, 2.40) that smoking increased the risk of stopping breastfeeding by 3 months (9). This meta-analysis did not examine the effect of smoking on intention to breastfeed or initiation of breastfeeding. In addition, maternal smoking was treated as a binary variable, with mothers being classified only as smokers or nonsmokers, and thus differences between heavy and light smokers were not investigated (9).

It is thought that nicotine has a negative effect on breastmilk supply by suppressing prolactin levels (7). Another article critically reviewed the possible mechanisms of the reduced duration of breastfeeding in lactating women, and the conclusions suggest that social and behavioral differences between smokers and nonsmokers may be more important than possible physiological effects of smoking (10).

In this review article we examine the relationship between maternal smoking and intention to breastfeed, initiation of breastfeeding, and duration of breastfeeding stratified according to amount of smoking. The primary question addressed in this paper is "Is there epidemiological evidence that maternal smoking has a negative physiological effect on breastfeeding?"

Although we present evidence of a dose-response relationship between maternal smoking and breastfeeding, we argue that this does not necessarily imply that tobacco use per se causes the lower rates of breastfeeding seen in women who smoke. If the relationship between maternal smoking and breastfeeding is purely physiological, we would expect that smokers and nonsmokers would have similar rates of intention to breastfeed and initiation of breastfeeding. If cigarette smoking causes mothers to have a significantly and consistently reduced milk supply, we would expect that a high proportion of smokers would stop breastfeeding in the early postpartum period.

### Methods

The following data sources were used to identify articles or book chapters reporting epidemiological studies of maternal smoking and the effect on lactation:

- *The Cochrane Library* (Issue 2, 2001)
- *Medline* via PubMed (19 April 2001), *CINAHL* (2001/01), *Current Contents* via Ovid (2001/ wk

16), *Psychinfo* (2001/01), *Sociological Abstracts* (2000/12), *Dissertations Abstracts International* via ProQuest (15 May 2001) and *National Bibliographic Database* (National Library of Australia) via Kinetica (7 May 2001)

- Lactation Resource Centre, Australian Breastfeeding Association (which includes "grey literature") (21 May 2001)

Key words were "smoking" and "breastfeeding" or "infant feeding," and searches were conducted from the start of the database to the dates listed above. The *Journal of Human Lactation* and *Birth* were hand searched from 1985 to the end of 2000. The search was not limited by study design, and all studies, apart from case reports, were included. References cited by these articles were also located whenever possible. Searches were conducted by one of the authors (LA), and articles were reviewed by both authors.

Each paper was tabulated under the headings of citation, country, and year of study, the sample and how it was chosen or defined, definitions of smoking and breastfeeding, and relevant results. All papers were initially tabulated, but only three tables are presented in this article: maternal smoking and intention to breastfeed, initiation of breastfeeding (multivariate studies only), and duration of breastfeeding stratified according to amount of smoking. The papers in these tables are all cross-sectional and cohort studies; sample size and method of recruitment were included to help readers assess study quality. Papers that described possible mechanisms of the reduced duration of breastfeeding in lactating women (e.g., prolactin levels, fat content in breastmilk, infant colic) were tabulated separately (10).

### Methodological Problems

Epidemiological studies of breastfeeding are often hampered by inadequate definitions of breastfeeding and inadequate collection or analysis of confounding variables (11). Studies of the relationship between smoking and breastfeeding are difficult, since women may be defined as smokers according to whether they were smoking in early pregnancy, late pregnancy, or the postpartum period. Comparisons are difficult because the proportions of women who smoke and women who breastfeed vary widely among studies. Several reports are secondary analyses of data sets that were not originally designed to investigate the relationship between smoking and breastfeeding, for example, references (12–15).

Although smoking is closely linked to confounding factors, such as mother's age and socioeconomic

status, many studies failed to account for these factors, which greatly influence infant feeding decisions. In those studies that adjusted for confounding factors, some adjusted only for maternal education, which may underadjust for socioeconomic status (14). Other studies have overcontrolled, such as those by Ford et al (12) and Clements et al (16) that have adjusted for bed-sharing, when this variable is closely associated with breastfeeding.

It is important to study initiation and duration of breastfeeding separately, since the women who “never start breastfeeding” appear to be a distinct category and not part of the “breastfeeding continuum” (17). Studies were separated into whether they reported breastfeeding intention, initiation, or duration. Only a

small number of studies reporting breastfeeding intention were located, and these are all included in Table 1. Since many studies reported smoking and breastfeeding initiation, only those that conducted multivariate analysis were included in Table 2.

Most studies present smoking as a dichotomized variable: women are either smokers or nonsmokers. However, differences exist between light smokers and heavy smokers (18), and in some respects light smokers may be more similar to nonsmokers than heavy smokers. In addition, the effect on lactation may vary in response to the wide range of nicotine levels in mother, breastmilk, and infant. Therefore, studies that stratified smoking status according to number of cigarettes smoked daily and reported the

**Table 1. Maternal Smoking and Intention To Breastfeed**

<i>Author, Country and Year(s) of Study</i>	<i>Sample, Definition of Smoking<sup>a</sup>, Percent of Sample</i>	<i>Results</i>																					
O'Campo et al, 1992 (20) Baltimore, USA, 1985–86	Women recruited through private and public obstetrical practices prenatally; <i>n</i> = 1900; prepregnancy smoking 32%	Smokers 25% intended to breastfeed, nonsmokers 49% ( <i>p</i> < 0.001) (Univariate analysis) RR = 2.0 <sup>b</sup>																					
Barnes et al, 1997 (21) Bristol, UK, 1991–92	ALSPAC study, birth cohort at 32 wk pregnant; <i>n</i> = 11,907; smoking at 32 wk pregnancy 18.5%	Intending to breastfeed at least 1 wk: Smokers 15+/day Adj RR 1.0 Smokers 1–14/day Adj RR 1.4 (95% CI 1.1, 1.8) Nonsmoker Adj RR 1.8 (95% CI 1.4, 2.3) Adjusted for maternal age, maternal education, paternal education, parity, whether mother breastfed, maternal body shape concern, social network, maternal attitudes to baby, housing status, social support, Edinburgh Postnatal Depression Scale score, partner affection score																					
Higlett, 1997 (22) Victoria, Australia, 1993	Survey of Recent Mothers, postal questionnaire of birth cohort at 6 mo; <i>n</i> = 1336; smoking in pregnancy 19%	Intended to breastfeed: smokers 88.2%; nonsmokers 92.7% (Univariate analysis) RR = 1.05 Planned length of breastfeeding: <table border="1"> <thead> <tr> <th></th> <th><i>Smoker</i></th> <th><i>Nonsmoker</i></th> </tr> </thead> <tbody> <tr> <td>Bottle</td> <td>11.8%</td> <td>7.3%</td> </tr> <tr> <td>Breast &lt; 3 mo</td> <td>6.7%</td> <td>3.8%</td> </tr> <tr> <td>Breast 3–5 mo</td> <td>9.4%</td> <td>8.6%</td> </tr> <tr> <td>Breast &gt; or 6 mo</td> <td>28.0%</td> <td>40.1%</td> </tr> <tr> <td>Breast: no plans length</td> <td>41.3%</td> <td>37.7%</td> </tr> <tr> <td>Uncertain</td> <td>2.8%</td> <td>2.5%</td> </tr> </tbody> </table> ( <i>p</i> = 0.003)		<i>Smoker</i>	<i>Nonsmoker</i>	Bottle	11.8%	7.3%	Breast < 3 mo	6.7%	3.8%	Breast 3–5 mo	9.4%	8.6%	Breast > or 6 mo	28.0%	40.1%	Breast: no plans length	41.3%	37.7%	Uncertain	2.8%	2.5%
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Bentley et al, 1999 (89) Baltimore, USA, 1992–94	African-American women recruited in prenatal clinic associated with WIC; at 10–24 wk gestation; <i>n</i> = 441; smokers 24%	Intended to breastfeed: smokers 31.1%; nonsmokers 47.2% ( <i>p</i> < 0.05) (Univariate analysis) RR = 1.5																					
Haslam, 1999 (90) UK, yr of study not stated	All women attending an antenatal clinic in 2 wk; <i>n</i> = 254; smokers 24%	Intended to breastfeed: smokers 45%; ex-smokers 64%; nonsmokers 69% ( <i>p</i> < 0.05) (Univariate analysis) RR = 1.53																					
Najdawi & Faouri, 1999 (19) Aqaba, Jordan, 1998	Selected cohort of women with full-term, healthy infants; <i>n</i> = 500; smokers 18.6%	Intended to breastfeed: smokers 88%; nonsmokers 91% ns																					

<sup>a</sup> Where definition of smoking is stated; <sup>b</sup> univariate analysis only presented when no multivariate analysis has been conducted.

ALSPAC = Avon Longitudinal Study of Pregnancy and Childhood (now known as Avon Longitudinal Study of Parents and Children); WIC = Special Supplemental Nutrition Program for Women, Infants and Children.

Adj RR = adjusted relative risk; ns = not significant.

relationship between smoking and the duration of breastfeeding were tabulated separately (Table 3). It should be noted that all studies presented in the tables relied on self-reported tobacco use.

## Results

### *Breastfeeding Intention*

Table 1 lists the six studies that investigated the association between maternal smoking and women's infant feeding intentions. Five found a significant relationship between smoking and artificial feeding; the difference was not significant in the Jordanian study (19). In 1992, O'Campo et al reported that women smoking around the time of pregnancy were less likely to intend to breastfeed, and asserted that this association had not been previously reported (20). The large population-based study in the United Kingdom (Avon Longitudinal Study of Pregnancy And Childhood) found a dose-response relationship between number of cigarettes smoked and intention to breastfeed, although the difference between light smokers and nonsmokers was not significant after adjustment for confounding factors (21). The Survey of Recent Mothers in Victoria, Australia, found a large difference between the proportion of nonsmokers planning to breastfeed for 6 months or longer (40%) and smokers (28%) (22).

### *Breastfeeding Initiation*

Many studies have reported an association between smoking and lower rates of initiation of breastfeeding on univariate analysis (16,22–31). Higlett found a dose-response-like effect of the number of cigarettes smoked per day by pregnant women in Victoria, Australia, and the rate of breastfeeding initiation. Her unpublished thesis describes an initiation rate of 91.3 percent for nonsmokers, 89 percent for women smoking 1–9 cigarettes, 83 percent for 10–20 cigarettes, 78 percent for 21 or more cigarettes (proportion of smokers estimated from figure) (22). The difference between nonsmokers and light smokers (1–9 cigarettes/day) was not significant.

Studies that conducted multivariate analysis were included in Table 2. Studies in which the sample size was less than 200 reported that the relationship between smoking and lower rates of breastfeeding initiation was no longer significant when any of the confounding factors (e.g., maternal age or education) were adjusted for. Larger studies generally found that the association between smoking and shorter duration of breastfeeding was maintained after adjustment.

Ford et al reported that only smokers who smoked more than 20 cigarettes per day were less likely to be exclusively breastfeeding on hospital discharge than nonsmokers after controlling for possible confounding factors (12).

Women who stopped smoking before or during pregnancy were just as likely to start breastfeeding as nonsmokers after adjustment for confounding factors (14,32,33). These studies showed an actual trend for women who stopped to be more likely to initiate breastfeeding (14,32,33). Women who stopped smoking in pregnancy and restarted smoking behaved more like smokers in respect to method of infant feeding (14,20).

Only four studies did not report a significant difference in initiation rate between smokers and nonsmokers: a United States study of "high-risk" women with a mean age of 21.8 years ( $n=2124$ ), of whom 50 percent smoked during pregnancy and approximately 20 percent initiated breastfeeding (34); a survey of 330 women in Geneva, who had a 93 percent breastfeeding initiation rate (35); and a study of 77 women in a Mohawk community, of whom 50 percent smoked (36). A study of more than 4000 women in South Carolina in 1960–1961 found no relationship between smoking and method of infant feeding (37). Breastfeeding was not defined in this study, but seems to refer to breastfeeding initiation. In contrast to later studies, there was a trend for heavier smokers to be more likely to breastfeed than nonsmokers: in the subgroup of black women with low socioeconomic status ( $n=2445$ ), 58 percent of women smoking more than one pack per day breastfed compared with only 46 percent of nonsmokers (37).

A study investigating risk factors for delayed onset of lactation ( $n=192$ , 7% smokers) found no association between smoking and women's perception of when the onset of lactation occurred (38). However, the number of smokers in this sample was small and it was not reported how many of the smokers initiated breastfeeding (initiation rate was 75% of total sample) (38).

### *Breastfeeding Duration*

Studies that have stratified smoking status according to number of cigarettes smoked daily, and reported the relationship between smoking and the duration of breastfeeding were listed in Table 3. The table includes the 10 studies located.

Significant differences are reported between the behavior of women smoking small numbers of cigarettes per day and heavy smokers. Several studies found that the difference between nonsmokers and women smoking lower levels of cigarettes is no longer

Table 2. Maternal Smoking and Initiation of Breastfeeding (Multivariate Analysis Only)

<i>Author, Country, and Year(s) of Study</i>	<i>Sample</i>	<i>Definition of Smoking (% of Sample) and Definition of Initiation</i>	<i>Results</i>
Mansbach et al, 1991 (17) Jerusalem, Israel, 1988 Pollock, 1992 (32) UK, 1970	Primiparas from lists of MCH stations; <i>n</i> = 190 British Births Survey, birth cohort; Primiparas <i>n</i> = 5917, Multiparas <i>n</i> = 9864	Smoking 6 mo after birth 23%; initiation of breastfeeding  Any smoking in pregnancy (% smokers not stated) Any breastfeeding in first wk	Initiation: nonsmokers 92.5%, smokers 79.5% ( <i>p</i> < 0.05) After adjustment for maternal education: smoking ns  Primiparas: Nonsmoker (OR of breastfeeding) 1 Stopped before/during pregnancy 1.17 (99% CI 1.03, 1.33) Smoked throughout pregnancy 0.85 (99% CI 0.76, 0.95) ( <i>p</i> < 0.05) Adjusted for: region of birth, maternal social class, maternal education, maternal height, mother's region of birth, contraceptive use, premarital conception, antenatal parentcraft class attendance, incubation of infant  Multiparas: Nonsmoker (OR of breastfeeding) 1 Stopped before/during pregnancy 1.11 (99% CI 0.99, 1.25) Smoked throughout pregnancy 0.84 (99% CI 0.76, 0.93) ( <i>p</i> < 0.05) Adjusted for: region of birth, maternal and paternal social class, paternal education, maternal age, mother's region of birth, contraceptive use, antenatal labor preparation class attendance, incubation of infant
Ford et al, 1994 (12) New Zealand, yr of study not stated	New Zealand Cot Death Study control infants; <i>n</i> = 1529 (age 1–52 wk)	Smoking in pregnancy (31.3%) and smoking in last 2 wk (32%); only 7.8% smoked 20+ cigarettes; exclusive breastfeeding at hospital discharge	Univariate analysis: smoked during pregnancy: OR not exclusive breastfeeding at discharge: 1.65 (95% CI 1.24, 2.20) Multivariate analysis: smoking 20+ cigarettes/day in last 2 wk: adj OR: 1.90 (95% CI 1.20, 3.02) Adjusted for occupational status, infant's sex, ethnic group, age mother left school, married, maternal age, age mother at first pregnancy, number of previous pregnancies, month pregnant when first attended antenatal clinic, attendance at antenatal classes, birthweight, gestation, infant admitted to neonatal intensive care, bed-sharing, dummy (pacifier) use
Nolan & Goel, 1995 (33) Ontario, Canada, 1986–90	1990 Ontario Health Survey; <i>n</i> = 3120	Smoking = smoking daily within 1 yr of last pregnancy (% smokers not stated); breastfeeding initiation (69.1%)	Smoking status: Never: Adj OR 0.71 (95% CI 0.48, 1.05); ROR 1.25 never vs daily Daily: 0.57 (95% CI 0.38, 0.85); ROR 1.75 former vs daily Former: 1.00 Adjusted for birthplace, employment status, language, marital status, education, age of mother
Sayers et al, 1995 (67) County Kildare, Ireland, 1993	Birth cohort; <i>n</i> = 145	Smoking at time of interview, within 14 days of birth (30.3%); breastfeeding initiation (overall 38%)	Smokers less likely to commence breastfeeding ( <i>p</i> < 0.05) Adjusted for social class: ns
Edwards et al, 1998 (14) Ottawa-Carleton region, Canada, 1993	Birth cohort; <i>n</i> = 769	Smoking at time of interview, 3 mo postpartum (16.6%); breastfeeding initiation	Nonsmokers 91.1% ; quit smokers 83.6%; current smokers 73.5% ( <i>p</i> < 0.001) Multivariate analysis: OR of bottle-feeding at birth: Nonsmoker 1.0 Quit smoker 0.79 (95% CI 0.44, 1.43) Current smoker 3.01 (95% CI 1.89, 4.78) Adjusted for maternal age, marital status, country of birth, education

Table 2. Continued

Author, Country, and Year(s) of Study	Sample	Definition of Smoking (% of Sample) and Definition of Initiation	Results
Riva et al, 1999 (73) Italy, 1995	National survey, random sample; $n = 1601$	Smoking during pregnancy (15%); breastfeeding initiation (overall 85.3%)	Nonsmokers 87% breastfeeding initiation 1–5 cigarettes/day 79% 6–15 74% > 15 80% ( $p < 0.001$ ) Not significant on multivariate analysis Adjusted for maternal age, education, social class, body mass index, mother having been breastfed, breast preparation during pregnancy, nursing guidance in maternity ward, duration of stay in maternity ward, parity, infant gender
Noble et al, 2001 (91) Bristol, UK, 1991–92	ALSPAC study, birth cohort; $n = 10,530$	Smoking at 32 wk pregnant (18.2%); breastfeeding initiation (79%)	Smokers have adjusted OR of initiating breastfeeding 0.72 (95% CI 0.62, 0.82) Adjusted for plans to work postpartum, maternal age, education, parity, ethnicity, attended childbirth classes, mother having been breastfed, infant birthweight

ns = Not significant; adj OR = adjusted odds ratio; RR = relative risk; ROR = relative odds ratio.

ALSPAC = Avon Longitudinal Study of Pregnancy and Childhood (now known as Avon Longitudinal Study of Parents and Children).

present after multivariate analysis: fewer than 20 cigarettes per day (16,39), less than 10 cigarettes per day (12).

Matheson and Rivrud stratified for maternal educational level as well as for level of smoking. Within each educational level a gradient was present among nonsmokers, light smokers, and heavy smokers (Table 3) (40). Najdawi and Faouri stratified for educational level, and reported that breastfeeding rates varied from 43 percent in smokers with 6 or less years of education to 86 percent in smokers with at least 17 years of education, compared with 84 to 94 percent for nonsmokers (19). Likewise, breastfeeding rates at 4 months varied from 33 percent for smokers on a low income to 60 percent for those on a high income, compared with 72 to 97 percent for nonsmokers (19).

Higlett analyzed smoking during pregnancy and smoking at the time of data collection, 6 to 7 months postpartum, and found similar dose-response-like effects on breastfeeding duration (22). Since most studies collected data on smoking during pregnancy only, it is reassuring that this measurement seems consistent with studies that examined postpartum smoking. It should be noted that smoking 1 to 9 cigarettes per day is only “just significant” after adjusting for confounding variables, including maternal age and education.

Without stratifying the amount of cigarettes smoked, many studies reported maternal smoking and breastfeeding duration. A large number that observed an association between maternal smoking and a shortened duration of breastfeeding relied on univariate analysis only (3,26,28,41–61). The consistent trend has been between smoking and earlier cessation of breastfeeding.

Studies that did not stratify according to number of cigarettes but conducted multivariate analysis are listed here: (13–15,17,30,32,33,62–76). With one exception, these studies found that smokers were likely to breastfeed for a shorter time than nonsmokers before adjusting for confounding factors. The exception was a New Zealand study of 350 mothers (10.5% smoked in pregnancy), which failed to find an association between smoking and shorter duration of breastfeeding (74).

As observed for breastfeeding initiation, studies in which the sample size was less than 200 found that the relationship between smoking and reduced duration of breastfeeding was no longer significant when any of the confounding factors (e.g., maternal age or education) were adjusted for. Larger studies generally reported that the association between smoking and shorter duration of breastfeeding was maintained after adjustment.

Table 3. Maternal Smoking (Stratified into Number of Cigarettes Daily) and Duration of Breastfeeding

Author, Country and Year(s) of Study	Sample, Definition of Smoking, Percent of Sample	Results
Woodward & Hand, 1988 (92) Adelaide, Australia, 1984	Intervention study to reduce infant passive smoking; $n = 99$ women who smoked in pregnancy; at follow-up: smoking = smoking 1 cigarette or more in previous wk 79%	Breastfeeding at 3 mo: 86% nonsmokers, 51% smokers ( $p < 0.05$ ) Nonsmokers (quitters): 88% 1–10 cigarettes/day 70% 11–20 cigarettes/day 43% 21 or more 29% Current smokers were compared with former smokers: smoking was an independent variable, after adjustment for low birthweight, illness in infant, parity, educational level, partner's occupation, lack of sleep (discriminant function analysis)
Matheson & Rivrud, 1989 (40) Oslo, Norway, 1985	Random sample; $n = 885$ ; smokers 39.6%	At 3 mo: nonsmokers 90% breastfeeding, smokers 65% breastfeeding ( $p < 0.001$ ) At 4 mo: prevalence of breastfeeding within each educational group, (estimated from figure): Years education    Nonsmokers 1–10 cigarettes/day    11–30 cigarettes/day 9 or less    70%    38%    8% 10–12    73%    52%    45% 13–16    80%    77%    55% 17 or more    92%    92%    50%
Labrecque et al, 1990 (93) Quebec City, Canada, 1985–86	Telephone survey at 2 wk; $n = 879$ ; 24% smokers	Nonsmokers: 62.6% breastfeeding; smokers 37.5% 1–10 cigarettes, 17.7% 11–20 cigarettes, and 14.6% 20+ cigarettes/day Adj RR nonsmoker 1.0; 1–10 cigarettes: 0.69 (95%CI, 0.53, 0.90); 11+ cigarettes: 0.35 (0.24,0.51) Adjusted in logistic regression model for maternal age, education, home district area
Ford et al, 1994 (12) New Zealand, yr of study not stated	New Zealand Cot Death Study, control infants; $n = 1529$ ; smoked in pregnancy 31%	Univariate analysis: Smoked during pregnancy: OR of not exclusively breastfeeding at 4 wk: 1.48 (95% CI, 1.15, 1.92) $p < 0.01$ ; Smoked in last 2 wk: OR of not exclusively breastfeeding at 4 wk: 1–9 cigarettes/day and 10–19 cigarettes/day: ns; 20+ cigarettes/day 1.95 (95% CI, 1.24, 3.06) $p < 0.01$ Multivariate analysis: Adj RR of shorter duration of breastfeeding: 10–20 cigarettes/day 1.62 (95% CI, 1.12, 2.36); 20+ cigarettes/day 2.22 (95% CI, 1.49, 3.30) Adjusted for occupational status, infant sex, ethnic gp, age mother left school, number of previous pregnancies, month pregnant when first attended antenatal clinic, attendance at antenatal classes, birthweight, gestation, infant admitted to neonatal intensive care, bed-sharing, dummy (pacifier) use (Cox regression)
Clements et al, 1997 (16) SW Thames region, UK, 1990–91	SIDS Study, randomly selected infants; $n = 700$ ; smokers 17%	Univariate analysis: Smoking in last 2 wk associated with reduced duration of breastfeeding Cigarettes/day    OR    (95% CI) 1–9    1.65    (1.02, 2.67) 10–19    1.93    (1.18, 3.18) 20+    3.94    (2.29, 6.77) Multivariate analysis ( $n = 511$ ): smoking 20+ cigarettes/ day OR, 2.30 (1.16, 4.59) Adjusted for occupation, marital status, maternal age, age mother left school, number of previous pregnancies, month pregnant when attended antenatal clinic, antenatal education classes, method of delivery, infant sex, gestation, birthweight, ethnicity, multiple births, admission to neonatal unit, caffeine and alcohol intake in last 2 wk, bed-sharing, use of dummy (pacifier)

Table 3. Continued

Author, Country and Year(s) of Study	Sample, Definition of Smoking, Percent of Sample	Results			
		Cigarettes/day in pregnancy	Univariate hazard ratio (95% CI)	Adjusted hazard ratio (95% CI)	Univariate hazard ratio (95% CI)
Higlett, 1997 (22) Victoria, Australia, 1989 and 1993	Survey of Recent Mothers, birth cohorts; $n = 790$ and 1336; total $n = 2126$ ; smoking in pregnancy 19%	None	1.00		
		1-9	1.69 (1.36, 2.10)	1.36 (1.05, 1.77)	1.84 (1.37, 2.47)
		10-20	2.24 (1.80, 2.80)	1.92 (1.47, 2.53)	2.99 (2.30, 3.89)
		21 or more	2.85 (2.07, 3.92)	2.37 (1.63, 3.43)	2.62 (1.78, 3.86)
		Adjusted for maternal age, country of birth, completion of secondary education, tertiary education, analgesia in labor			
Horta et al, 1997 (39) Pelotas, Brazil, 1993	Birth cohort; $n = 1098$ ; smoking at 6 mo 28.6%	Smokers: Adj OR of not breastfeeding at 6 mo: 1.34 (95% CI, 1.00, 1.80)			
		Nonsmokers ( $n = 742$ )		1.00	
		<10 cigarettes/day ( $n = 142$ )		Adj OR, 0.99 (95% CI, 0.67, 1.45)	
		10-20 cigarettes/day ( $n = 94$ )		Adj OR, 1.61 (95% CI, 1.00, 2.61)	
		20 + cigarettes/day ( $n = 72$ )		Adj OR, 1.94 (95% CI, 1.10, 3.39)	
Nafstad et al, 1997 (85) Oslo, Norway, 1992-93	Birth cohort; $n = 3020$ ; smoking in pregnancy 23.5%	Adjusted for social class, maternal age, parity, birth interval, adequacy of antenatal care, use of oral contraceptive with estrogen, birthweight			
		Nonsmoker		75% breastfeeding > 6 mo	Multivariate (Cox regression)
		Light smoker (<10 cigarettes/day)		59% breastfeeding	Adj OR 1.3 (95% CI, 1.2, 1.5)
		Heavy smoker (10 or more cigarettes/day)		41% breastfeeding ( $p < 0.01$ )	Adj OR 2.0 (95% CI, 1.3, 2.3)
		Adjusted for maternal age, maternal education, family income, single parenthood, gender, birthweight			
Bouvier & Rougemont, 1998 (35) canton of Geneva, Switzerland, 1993	Random sample; $n = 278$ ; smoking postpartum, % not stated	RR of stopping breastfeeding by 4 mo:			
		< 15 cigarettes/day	1.49 (95% CI, 1.18, 1.89)		
		15 + cigarettes/day	1.99 (95% CI, 1.43, 2.77)		
Najdawi & Faouri, 1999 (19) Aqaba, Jordan, 1998	Selected cohort of women with full-term, healthy infants; $n = 500$ ; smokers 18.6%	Breastfeeding at 4 mo:			
		Nonsmokers ( $n = 360$ )	88%		
		<10 cigarettes/day ( $n = 53$ )	47%		
		> 10 cigarettes/day ( $n = 40$ )	40% ( $p < 0.05$ )		

Adj OR = adjusted odds ratio; RR = relative risk; ns = not significant.

## Discussion and Conclusions

It is widely believed that maternal smoking has a detrimental effect on breastmilk supply and that this is the primary reason that women who smoke are less likely to breastfeed their children (7). However, we should remember the comment by Mary Meyer: "we have no knowledge of these mothers' desire to breastfeed and cannot conclude that the differences were related to their ability to do so" (23, p 975). Some women believe that smoking is a barrier to breastfeeding; they do not believe they could, or should, adhere to the kinds of healthy practices they think are required of mothers to breastfeed (77).

The studies identified in this review provide evidence that women who smoke seem to have significantly less motivation to breastfeed: they are less likely to intend to breastfeed (Table 1) and less likely to initiate breastfeeding (Table 2). They may also be less likely to seek help with breastfeeding difficulties than nonsmokers (78). Although a dose-response-like relationship usually signifies a physiological relationship between variables, the dose-response relationship between number of cigarettes smoked and women's intention to breastfeed cannot indicate a physiological effect. Similarly, the dose-response relationship between number of cigarettes smoked and initiation of breastfeeding cannot be physiological. Both relationships must indicate the importance of social or behavioral factors in women's infant feeding decisions.

The dose-response relationship between number of cigarettes smoked each day and the duration of breastfeeding (Table 3) may indicate a physiological effect of cigarette smoke on lactation; however, the psychological or behavioral differences between women who are light smokers and heavy smokers (seen earlier in relation to intention and initiation of breastfeeding) may also contribute to this difference.

The two studies that appear to provide the strongest support for a physiological role for nicotine in inhibition of milk supply are by Hopkinson et al (79) and Vio et al (80). Yet, smoking only accounted for 8 percent of the variability of milk volume in Hopkinson et al's study of women expressing milk for their premature infants, whereas expressing frequency, change in frequency, and day of initiation of expressing accounted for 56 percent of the variability (79). Furthermore, breastmilk production is strongly influenced by mental attitude: breastfeeding is said to be a "confidence trick" (81). Mothers using a relaxation cassette were found to express 63 percent more breastmilk than a group of control mothers (82). It is not known if smokers share the same attitude toward establishing successful lactation as

nonsmokers; although we do know that only 6 of the 11 smokers were still expressing at 6 weeks postpartum compared with 25 of the 29 nonsmokers (79). Studies of breastfeeding intention and initiation do not support an equal desire to breastfeed among smokers and nonsmokers.

In other contexts, authors have expressed concern that smoking is used to "explain" child ill health (83) and mortality risk for the smoker (84). Logan and Spencer argued that smoking should be seen as "only one factor within a complex constellation of adverse influences strongly correlated with social and environmental circumstances" (83, p 176). Current statistical techniques for controlling for confounding in multivariate analysis are limited and may lead to overemphasis of single factors such as smoking (83).

Several studies provide evidence that smoking does not necessarily hinder breastfeeding. Nafstad et al reported that 41 percent of Norwegian women who smoked 10 or more cigarettes per day were continuing to breastfeed at 6 months postpartum (85). Likewise, 86 percent of Jordanian women smokers with at least 17 years of education were breastfeeding at 2 months (19). In some populations, for example South Carolina in the early 1960s (37) and urban aboriginal women recently in Western Australia, a high proportion of women both smoke (65% in pregnancy) and breastfeed (89% initiation, 70% at 6–12 wk postpartum) (86). If nicotine had a consistently negative effect on lactation, we would not be seeing these examples of successful lactation in smoking women.

Qualitative studies may be helpful to understand women's views of smoking and breastfeeding, and to ascertain what strategies would be helpful to women who smoke. One study of smoking relapse found that stopping breastfeeding was associated with a return to the "normal" or nonpregnant state and sometimes marked a return to smoking (87). Perhaps some women believe that they should not smoke and breastfeed, so they give up breastfeeding so as to go back to "ordinary life."

Trials of smoking cessation interventions in pregnancy should include breastfeeding initiation and duration in their outcome data (88).

The association between maternal smoking and lack of breastfeeding is consistent across different study designs in a range of countries. Given the evidence presented in this paper, however, particularly that women who smoke are less likely to intend to breastfeed, it cannot be assumed that the relationship between smoking and duration of breastfeeding is a physiological one. If smoking had a consistent negative physiological effect on lactation, we would not expect to see such wide variations in breastfeeding

rates among women who smoke. Therefore, it is likely that psychosocial factors are largely responsible for the lower rates of breastfeeding found in women who smoke compared with those who do not smoke.

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